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CIRCULAR No. 170
SEPTEMBER, 1917

FERTILIZING CALIFORNIA SOILS FOR THE 1918 CROP[1]

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GENERAL CONSIDERATIONS

The statements made below with reference to the proper systems of fertilization which can be followed on California soils during the next two or three years will be almost entirely limited to the phase of fertilization connected with the use of commercial fertilizers. For that reason the nitrogen, phosphoric acid, and potash situations will be treated chiefly.

In connection with all of the considerations on the use of fertilizers on California soils either during the period of war or during other times when high prices obtain, it must be remembered that the ruling factor is the economic one. During the period of the war, the chief desideratum is maximum yields, inasmuch as the food supply of this country and that of her allies is bound to be limited even if maximum yields are obtained. If, therefore, the producer of crops can make no profit, but also incurs no loss, by the use of fertilizers, but can make every acre of his land produce more in a given season by the use of such fertilizers, it would seem to be his clear duty as a patriot to employ fertilizers in his cropping operations. But another side to the situation appears in time both of war and of peace when high prices for crops reign. That is, that while in times of moderate or low prices it is unprofitable, even though the crop be increased thereby, to use fertilizers on certain classes of crops, the practice of fertilization will prove highly profitable when prices for products are high. So far as California farmers are concerned, this situation is particularly true of the cereals and other ordinary field crops.

[1] It is assumed in this circular that the reader understands that fertilizer treatment of soils is merely a supplementary measure in the handling of soils, and that it must fall far short of the best results if proper tillage, planting, and other operations are not insured, particularly in the case of annual crops.

THE CHIEF NEEDS OF CALIFORNIA SOILS

It is a truism that nitrogen and organic matter are the most important factors in the fertility of agricultural soils the world over. This applies nowhere with such great force, however, as in the case of the arid soils of California and in that of similar arid soils elsewhere. Everywhere the pre-eminent factor in soil fertility, the question of the nitrogen supply, because of the great scarcity of that element which characterizes arid soils, is far more acute, and far more one of present moment in California than elsewhere. With the nitrogen question is indissolubly linked the organic matter question, since the organic matter supplies most of the nitrogen upon which successful crop growth depends, and since moreover certain essential transformations of the nitrogen in soils depend on the proper supply of the organic matter. It is, therefore, urged with all the force which we can command that the producer of crops in California recognize first and foremost that his problem in the maintenance of fertility in California soils lies chiefly in supplying his soils with, and maintaining therein, as large a supply of nitrogen as he can with financial profit, or even without loss.

HOW TO SUPPLY ORGANIC MATTER

Without going into detail on the questions of methods for supplying organic matter which have been, or will be, discussed in other experiment station publications, it may be briefly stated that the following means are available for adding to the organic matter supply of California soils. One or more of the methods recommended may have to be used in order to obtain the best results.

1. The use of all available farm manure, including all that can be purchased at low rates.

2. The use in orchards and vineyards in the fall of the year and on summer fallowed grain land during the fallow year, of all available straw of whatever kind, including that which can be purchased at very low rates.

3. The use of green manuring crops, preferably the leguminous crops, grown throughout the winter and spring and plowed under about April first. The choice for these crops should be made from the following, preference being given in the order named: *Melilotus indica,* vetch, and bur clover.

4. Weeds from neglected fields, beet tops, other similar plant refuse, and prunings from trees and vines may with good effect be incorporated with soil, especially in the fall of the year.

In addition to the use of all these manures, it should be constantly borne in mind that *conservation* of organic matter in the soil is fully as important as the addition of organic matter thereto. For that reason it is strongly urged that on orchard and vineyard lands, wherever possible, straw mulches[2] be employed as protective coverings to the soil. They preserve the organic matter of the soil in two ways, first by preventing excessive oxidation of the organic matter which results from cultivation with its attendant large introduction of oxygen and increased temperatures, and, second, by the addition of a portion thereof to the soil. Even if such mulching cannot be followed for more than a period covering the summer months, say from April 15 to November 1, it will be of great advantage. The best mulches, owing to their high nitrogen contents, are, of course, the legume straws like bean straw, pea straw, coarse alfalfa hay, and similar substances. In their absence, however, the grain straws like oats, barley, wheat and rice may be used. Rice hulls will also serve as valuable mulching material and where a plentiful supply of farm manure is available, it may also be used for that purpose.

NITROGEN

Our investigations on the nitrogen content of California soils have shown that in the truly arid parts of the state, the great majority of soils contain less than .05 per cent of nitrogen. This means a maximum of 2000 pounds per acre foot, or 6000 pounds in the upper three feet. Only a small portion of the total nitrogen contained in soils can become available for use by plants, in the growing season, by its proper transformation through bacterial agencies, and an ordinary barley crop will probably remove sixty pounds of nitrogen per acre. The nitrogen which we can count on for plant growth is properly nitrified only in the top eighteen inches of soil, hence it can be readily appreciated that the supply of the important element in question is very limited and from the point of view of soil fertility is the chief factor to be taken into consideration at this time.

The Form of Nitrogen to Use.—Not only is the total nitrogen supply very limited in most of our soils, but owing to the lack of organic matter and the poor moisture conditions for the greater part of the year, the bacterial flora upon which we depend for rendering the nitrogen of soils available are less efficient than the bacteria in soils of the eastern states where rain falls the year around. This is par-

[2] It is to be borne in mind in connection with the use of straw mulches that there is always danger of fire and precautions must be taken to prevent it. Leaving every other middle or every third middle unmulched will minimize the danger considerably.

ticularly true insofar as the transformation of organic nitrogen into nitrates is concerned. On the other hand, some forms of commercial fertilizer nitrogen have been found to stimulate these bacteria to a relatively high efficiency and at the same time are quickly made available to crops. While it is impossible to make general statements of absolute value for every soil in the state, it is, nevertheless, true that certain general rules for the use of nitrogenous fertilizers in California may be formulated on the basis of our studies. They may be stated briefly as follows as regards the form of nitrogen to employ:

1. In the soils of the San Joaquin Valley and in those of the southern valleys of California, including the southern coast valleys, the southern portion of the Sacramento Valley, and in other places where the rainfall is below sixteen inches per annum, it appears that a high grade inorganic nitrogenous fertilizer is to be preferred to the organic forms and especially where quick results are desired. The best representative of the high grade nitrogenous fertilizers for the class of soils under consideration here is sulphate of ammonia. It may be used on all crops in the case of these soils. Nitrate of soda may be used also in the case of grain soils with good effect. Our investigations have shown that both nitrate of soda and sulphate of ammonia are very effective in increasing enormously the crop of grain on nitrogen-poor soils, such as those here concerned; and in the case of orchard soils that sulphate of ammonia is to be preferred to nitrate of soda, and particularly on the heavier soils of the citrus growing districts.

2. On soils of the northern and northwestern counties of the state, including a considerable portion of the north half of the Sacramento Valley and in some of our more southern coast valleys, together with a few more isolated and limited districts all over the state, in which the soils contain more than the usual quantity of organic matter and of nitrogen, the high grade organic nitrogenous fertilizers will serve as well. In these regions they are superior to the inorganic nitrogenous fertilizers, like sulphate of ammonia and nitrate of soda. On this class of soils, therefore, it is urged that high grade nitrogenous fertilizers, like dried blood, high grade tankage and fish guano, be given first choice, that the high grade inorganic nitrogenous fertilizers, like nitrate of soda and sulphate of ammonia be given second choice, and that the low grade organic nitrogenous fertilizers like cotton seed meal, steamed bone meal, and garbage tankage, be given third choice. Other considerations bearing on the choice of fertilizers will be given below.

Amounts of Nitrogenous Fertilizers to Employ.—In the case of barley, wheat, oats, rye, and field crops of relatively low value per

acre, it is recommended that on the first class of soils above mentioned, 125 pounds of nitrate of soda per acre or 100 pounds of sulphate of ammonia per acre be applied. For the same crops on the second class of soils it is recommended that the preference be given to dried blood or high grade tankage, used as follows: Dried blood, 200 pounds per acre; high grade tankage, 250 pounds per acre.

For orchard and vineyard crops on the first class of soil, sulphate of ammonia is recommended in amounts varying from 300 to 500 pounds per acre. The applications *need not* be made every year. Nitrate of soda, it seems, at the present time, best to *recommend against* for citrus orchards in southern California, since some investigations seem to point to bad effects on trees, resulting from its use for several years. Low grade organic nitrogenous fertilizers may be used with good effect in the case of the soils of the first class, but not with as good effect on soils of the second class, nor with as good effect as sulphate of ammonia. When dried blood and high grade tankage are used on orchard soils, however, they should be applied at the rates, respectively, of 500 to 800 pounds, and 600 to 1000 pounds per acre.

When and How to Apply Nitrogenous Fertilizers.—Our investigations have not as yet indicated with exactitude the most propitious time for the application of nitrogenous fertilizers for crops. They have, however, given some hints in that direction which are considered valuable and the following statements may be made as a result. When application of the fertilizer in question is determined in the case of winter grain, nitrate of soda or sulphate of ammonia should be applied as a top dressing on the standing grain in the month of February wherever possible. In the case of spring grain, these fertilizers may be applied between the middle of March and the middle of April, especially if there is promise of further rain for that season. Dried blood, high grade tankage, or similar material should be applied prior to the preparation of land for the grain crop and plowed or cultivated in. In the case of orchard crops, it is best to consider the irrigated, and the unirrigated, as well as the deciduous and the citrus orchards separately. In citrus orchards, it is best to apply sulphate of ammonia in from three to five applications, employing about one pound per tree per application, in the months of February, March, and April, or similarly from January to May. If organic nitrogenous fertilizers be used, the application should be made in the fall or early winter and cultivated or plowed in, preferably at one application. If plowing or cultivating is done later in the spring, it will be advisable to put off the application of these fertilizers until the month of February or March. In the case of irrigated deciduous orchards, the same

rules will apply as in the case of the citrus orchard, except that the minimum rather than the maximum application should be employed and the application made in the spring months exclusively.

On the unirrigated deciduous orchards and vineyards, the application of these fertilizers should be made not later than the first of March in the case of sulphate of ammonia and nitrate of soda, and preferably a month earlier, in the case of organic nitrogenous fertilizers.

The Cost of Nitrogenous Fertilizers.—The economics of the fertilizer situation is fully as important as all other considerations and perhaps more so. It is for that reason that the general comment regarding the use of fertilizers in the present emergency was made in the introductory remarks above. In addition thereto, however, some observations need to be made at this point. Wherever the use of certain forms of nitrogenous fertilizers is not specifically discouraged, the first consideration in the choice of a fertilizer should be the cost at which a certain number of pounds of nitrogen may be obtained. Therefore, even though, for example, 100 pounds of sulphate of ammonia per acre is preferred for a barley crop in southern California or in the San Joaquin Valley, to 165 pounds of dried blood, which contains about the same amount of nitrogen, the latter should be chosen if that quantity of dried blood can be obtained for less money than the quantity of sulphate of ammonia mentioned. The opposite will be true where dried blood or the class of materials it represents is to be preferred to the inorganic nitrogenous fertilizers as above explained. The freight charges on the fertilizers to a given ranch must also be taken into consideration when the calculations above referred to are made, so that the actual cost of the fertilizer to the farmer, including the cost of application or incorporation with the soil should be completely computed before the choice of a fertilizer is made. It is remarked further that the amounts of fertilizers recommended for use, especially for grain and field crops, are often chosen because of the economics of the situation and not because larger amounts might not produce larger crops. It is actually true that larger amounts of sulphate of ammonia than 100 pounds per acre will produce larger grain crops than the amount just mentioned, but with the income from an acre of grain or other field crops it may not be possible to make larger applications of this material pay.

It is difficult to state for the use of our readers the prices of the fertilizers in question, for the reason that they are subject to constant change and because fertilizer materials have become particularly valuable during the period of the war. At the present writing, nitrate of soda may be obtained from $90 to $100 per ton and sulphate of ammonia at about $130 per ton. Another item, therefore, to take into consideration when making the calculations above indicated is the amount being paid per pound for nitrogen in a ton of a given fertilizer. Since the analysis of the fertilizer is always given, the number of pounds of nitrogen per 100 pounds or per ton and the

cost of a pound of nitrogen are easily determined. In this manner, two or more fertilizers can be compared in price very easily. Where fertilizers are sold on the so-called "unit" basis, the latter means merely that a unit stands for 1 per cent of a ton, or twenty pounds. Thus, if nitrogen sells for $5 per unit, it means that for every twenty pounds of nitrogen in a ton of a given fertilizer $5 is paid, or in other words, nitrogen costs 25 cents a pound. The same applies to the purchase of other fertilizer ingredients like phosphoric acid and potash.

This experiment station stands ready at any time to advise people regarding the choice of a fertilizer among several offered if the crop and location are stated and the price and analyses of the fertilizers are given.

PHOSPHORIC ACID

In general, it appears to be true that phosphate fertilizers cannot at the present time be made to yield profitable returns on the arid soils of California. While the amounts of phosphoric acid in our soils are not large, and, in general, about the same as those of eastern soils, the greater depth of our soils, which encourages at least slightly deeper feeding of plants than that characteristic of plants on eastern soils, appears to make it possible for crops to obtain the necessary phosphoric acid which they require for maximum growth at the present time. It is particularly emphasized in this connection that this is merely a general rule and like all rules has its prominent exceptions. During the period of the war, however, it seems pretty safe to discourage the use of phosphate fertilizers for any of our field crops except as specifically recommended below. In the case of our orchards also, with few exceptions, it seems undesirable and unprofitable now to employ phosphoric acid fertilizers.

There are, however, certain soil conditions in California in which the application of phosphates will pay and some instances in which no paying crop can be grown without their use. These conditions are very largely limited to the tule and overflow soils of the delta region of the Sacramento and San Joaquin rivers, in which, while the total amount of phosphoric acid may sometimes be fairly large, there is only a small quantity which is available for plant growth. The use of from 300 to 1000 pounds of superphosphate per acre, depending on the value of the crops grown, has in several instances been shown to be productive of excellent results. In all of the potato, asparagus, bean, and vegetable lands of our delta regions which consist chiefly of organic matter, it is recommended that superphosphate or some similar form of readily available phosphoric acid be employed for the increase of the crop. It is to be remembered here again that even if no great profit is to accrue from the employment of phosphoric acid fertilizers under such circumstances, it is the patriotic duty of the owner of such land to increase the crop output per acre, which he can do in this case by the use of the fertilizer recommended, certainly without loss, and in practically all cases with considerable profit.

There are some lands in the San Joaquin Valley, and particularly

those of the blow-sand type in the vicinity of Atwater, Livingston, Ripon, and similar regions, where it may pay to use phosphate fertilizers owing to the rather unusually low content of available phosphoric acid which characterizes those soils. Experimental data with respect to this matter are too meager at the present time to justify our making any recommendations for the use of phosphate fertilizers to the soils in question, though it is believed that on annual field crops profitable returns will result from the use of phosphate fertilizer on these soils provided the nitrogen, which is needed there even more than the phosphoric acid, is employed as above recommended.

In general, superphosphate may be purchased at approximately $18 per ton, thus making it a relatively low-priced fertilizer.

POTASH

With the possible exception of the delta soils, which are spoken of in connection with the phosphoric acid problem, it seems quite certain that potash fertilizers cannot be made to return profitable yields on arid California soils. In addition, it also seems true that the size of the crop may not be materially increased by the use of potash fertilizers, even without profit. Taking these facts together with the extraordinarily high prices which are now charged for potash fertilizers ($400 to $500 per ton of high grade sulphate or chloride of potash), it seems necessary to recommend at this time that potash fertilizers be not employed during the period of the war on California soils. The high prices for potash fertilizers are due to the fact that the chief source of supply of the world's potash has been at the Stassfurt mines in Germany, which, are, of course, at the present time, closed so far as the world, other than the Central Empires, is concerned. Various sources of potash are being developed in this country, but have not as yet reached the large output which is necessary to lower the present high prices for potash.

On the delta lands or similar soils consisting chiefly of organic matter, and on some of the badly leached soils of our northern and northwestern counties where excessive rainfall is obtained every year, potash fertilizers may be used to advantage if a cheap form like that of wood ashes is obtainable. Considerable amounts of wood ash result from the burning over of many of our timber lands following logging operations. These supplies of wood ashes will be a valuable asset to the leached soils mentioned above and if they can be obtained for use on these classes of soils at low rates, can undoubtedly be used there with profit in crop production and in some limited instances may even be instrumental in making a crop where otherwise practically none could be produced. Other materials may be used in lieu of the wood ashes under the circumstances named, if the cost of their production is not very great; for example, the ash of kelp, of weeds, of brush, of tule grasses, and of other organic materials containing potash will also serve acceptably if they can be obtained at relatively low prices, which necessarily will vary in accordance with the percentage of potash contained in the particular kind of ash.